University Microfilms
313 North 1st St
Ann Arbor Michigan

American
POTATO JOURNAL

Volume 38 *November 1961* *Number 11*

CONTENTS

Sprout inhibition of fall-grown potatoes by airplane applications of maleic hydrazide ..... J. C. Bishop and V. H. Schweers 377

Viricidal disinfestants for the potato cutting knife ..... L. C. Peterson, R. L. Plaisted and Jaime Diaz 382

Chemical control of potato seed piece decay ..... Roland F. Line and Carl J. Eide 388

Chipping tests of potato varieties and selections grown in North Dakota ..... R. H. Johansen and J. C. Hansen 396

NEWS AND REVIEWS

Improved handling and packaging methods for potatoes: How it is done in Maine (*Reprinted from Produce Marketing*) ..... Edward F. Johnson 407

Ingrown sprouts in potato tubers: Factors accompanying their origin in Ohio ..... Ralph Marshall Davis, Jr. 411

Work session on "Developing potatoes for processing" 414

NOTICE OF CHANGE IN MEMBERSHIP DUES 419

Official Publication of
THE POTATO ASSOCIATION OF AMERICA
NEW BRUNSWICK, NEW JERSEY, U. S. A.

American Potato Journal

PUBLISHED BY
THE POTATO ASSOCIATION OF AMERICA
NEW BRUNSWICK, N. J.

EXECUTIVE COMMITTEE

J. C. CAMPBELL, *Editor-in-Chief*
E. S. CLARK, *Associate Editor*
WM. H. MARTIN, *Honorary Editor*
Rutgers University, New Brunswick, New Jersey

ROBERT V. AKELEY, *President* .....U. S. Department of Agriculture, Beltsville, Md.
L. C. YOUNG, *President-Elect* ..Canada Dept. of Agriculture, Fredericton, N.B., Canada
WILLIAM G. HOYMAN, *Vice President* .....Irrigation Experiment Sta., Prosser, Wash.
RICHARD L. SAWYER, *Secretary* .....L. I. Vegetable Research Farm, Riverhead, N. Y.
JOHN C. CAMPBELL, *Treasurer* .....Rutgers University, New Brunswick, N. J.
ORRIN C. TURNQUIST, *Past President* .....University of Minnesota, St. Paul, Minn.
WALTER C. SPARKS, *Director* .....Agricultural Experiment Station, Aberdeen, Idaho
ROBERT H. TREADWAY, *Director* ....U. S. Department of Agriculture, Philadelphia, Pa.
HENRY M. DARLING, *Director* .....University of Wisconsin, Madison, Wis.

Price $4.00 per year in North America; $5.00 in other countries.
Not responsible for free replacement of non-delivered or damaged issues after 90 days.

Second Class Postage Paid at New Brunswick, New Jersey.

SUSTAINING MEMBERS

STARKS FARMS INC. .....Route 3, Rhinelander, Wisconsin
BACON BROTHERS .....1425 So. Racine Ave., Chicago 8, Illinois
L. L. OLDS SEED CO. .....Madison, Wisconsin
FRANK L. CLARK, Founder — Clark Seed Farms .....Richford, New York
RED DOT FOODS, INC. .....Madison, Wisconsin
ROHM & HAAS COMPANY .....Philadelphia, Pennsylvania
WISE POTATO CHIP CO. .....Berwick, Pennsylvania
AMERICAN AGRICULTURAL CHEMICAL CO. .....Carteret, New Jersey
LOCKWOOD GRADER CORP. .....Gering, Nebraska
E. I. DU PONT DE NEMOURS AND CO. (INC.)
Industrial and Biochemicals Dept. .....Wilmington 98, Delaware

SPROUT INHIBITION OF FALL-GROWN POTATOES BY AIRPLANE APPLICATIONS OF MALEIC HYDRAZIDE[1]

J. C. Bishop and V. H. Schweers[2]

The effectiveness of maleic hydrazide in inhibiting the post-harvest sprouting of potatoes has been previously demonstrated. Results in California have been reported (1, 2). In Kern and Tulare Counties of California, potatoes of the White Rose variety planted in August may be stored in the soil following the killing of the vines by late fall frosts until prices are favorable. When harvesting is delayed beyond the latter part of February, sprouting of tubers in the ground, besides lowering of potato quality, increases the cost and difficulties of harvesting, grading and washing operations. Huge quantities of sprouts and adhering soil must be removed in the packing sheds. In a preliminary trial conducted during 1957-1958 hand spraying with MH-40 controlled sprouting of tubers in the soil even when harvest was delayed until April 9 (Table 1). The specific gravity of soil-stored tubers was significantly higher in the plots where sprouting had been controlled (Table 1). The experiments herein reported were to determine the effectiveness of airplane applications of maleic hydrazide in reducing sprouting in the field as well as the effect on yield and quality of potatoes.

Materials and Methods

In the fall of 1958 and 1959 maleic hydrazide was applied by airplane as a spray at rates of 3 and 6 pounds per acre on actively growing White Rose potatoes in Tulare County, California. The spray mixture consisted of one gallon of MH-30 to 9 gallons of water and contained 3 pounds of actual maleic hydrazide. The plane made a swath, ¼ mile long and 12 rows wide, across the field for the 3 pounds per acre rate. Another area the same size received 2 passes of the plane, thus applying 6 pounds per acre.

Six plastic sheets, each covering an area 4 rows wide and 50 feet long, were placed at 50 foot intervals over the center 4 rows of each of the 12-row swaths prior to application of the maleic hydrazide. The areas covered with the plastic sheets thus provided 6 replications of the untreated plants for each of the 2 rates of application. Six replications for each rate came from the treated areas between the plastic sheets. Only tubers of plants from the center 4 rows were used in the study. Applications were made on October 30 in 1958, and on November 3, 1959, 17 and 32 days, respectively, before death of the foliage from frost.

At harvest time, February 26, 1959 and March 23, 1960, respectively, the weight of sprouts adhering to the tubers in the field, as well as total yield, were measured. Twenty pounds of desprouted tubers from each

[1]Accepted for publication April 3, 1961.

[2]Department of Vegetable Crops, University of California, Davis, California; and Agricultural Extension Service, University of California, Visalia, Calif.

The authors wish to express their appreciation for the cooperation of J. A. Wilkerson and Jack P. Corkins of Naugatuck Chemical Division of United States Rubber Company for supplying the chemical and residue analyses; W. L. Kiggens, Mel Schlitz and Rex Vosburgh of Delano-Earlimart Potato Growers, Inc., John Saylor of Earlimart, and Hodges Crop Dusters and Earlimart Dusters.

TABLE 1.—*The effect of hand-sprayed MH-40 on the sprouting and specific gravity of soil stored fall-grown potatoes at harvest on April 9, 1958.*

Pounds of maleic hydrazide per acre[1]	Number of sprouts per 100 pounds of tubers		Specific gravity
	Under 4"	Over 4"	
none	80	100	1.058
1.2	2	9	1.069
3.6	2	2	1.069
7.2	0	1	1.067
L.S.D. 5%	19	28	0.007

[1]MH-40 was applied to plants on October 26, 1957.

treatment replication were placed in common storage. The storage temperature increased initially from about 50 F at the beginning to about 65 F to 68 F at the termination of the storage period. On April 16, 1959 and May 10, 1960, tuber samples were removed from common storage. Sprouting and tuber weight loss were measured. At harvest time 5-pound tuber samples from each plot were analyzed for maleic hydrazide. Specific gravity of tubers was determined by means of a potato hydrometer at harvest and after storage.

RESULTS

In the first trial in 1958, tubers harvested February 26, 1959 showed no sprout development. However, in the later experiment tubers which were harvested March 23, 1960 from the treated plots were found to have an average of one ounce of sprouts per 100 pounds of tubers in the field picking sacks; tubers from the untreated plots had developed in excess of 2 pounds of sprouts per 100 pounds (Table 2).

At the termination of the common storage period in both years, it was evident that MH-30 was effective in controlling sprout development (Table 2 and Fig. 1). Both number and weight of sprouts were lower for the treated than for the untreated lots. This was particularly true of sprouts over 4 inches in length. Both the 3 and 6-pound rates of MH were effective in reducing sprouting. The larger sprouts are the most troublesome at harvest because of the accompanying root development which occurs under soil-storage conditions.

The percentage weight loss of tubers in storage (Table 3) was less for the treated than the non-treated lots, due primarily to the reduction in sprout development. In the 1959 study, the tubers from the plots receiving the 6-pound rate lost more weight than did those from the 3-pound treatment. However, in the 1960 trial the difference between rates was not significant.

Total tuber yield (Table 4) was not significantly affected by the MH-30 applications in either year of study regardless of the rate of application.

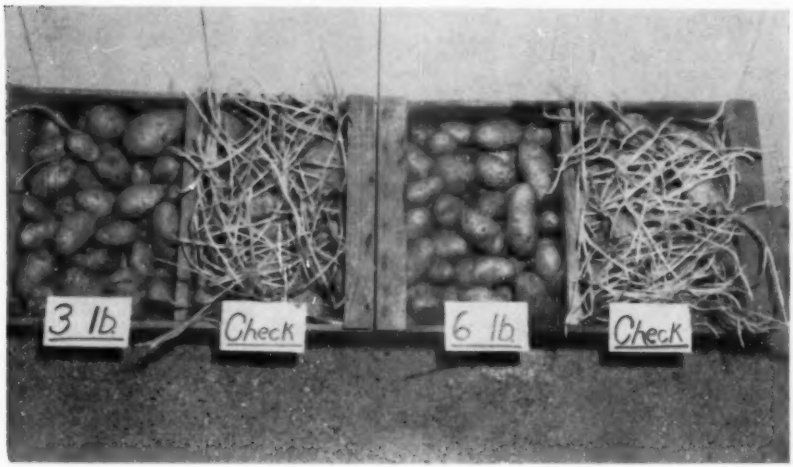

FIG. 1.—The effect of 3 and 6 pound rates of maleic hydrazide, as MH-30, applied by airplane on sprouting of tubers in common storage. Photographed on May 10, 1960.

TABLE 2.—*The effect of maleic hydrazide, as MH-30, applied by airplane on sprouting of fall-grown potatoes.*

Amount of maleic hydrazide applied	Sprouts per 100 pounds of tubers							
	In field sacks at harvest 1959-1960 Wt. oz.	At end of storage period						
		1958-1959				1959-1960			
		Under 4"		Over 4"		Under 4"		Over 4"	
		no.	wt. oz.	no.	wt. oz.	no.	wt. oz.	no.	wt. oz.
3 pounds per acre	1	54	1	14	1	209	2	22	3
Untreateed	33	588	11	165	14	746	12	695	66
6 pounds per acre	1	27	1	9	9	39	1	39	4
Untreated	34	607	12	218	17	686	11	776	78
L.S.D. 5%	9	99	2	39	4	152	3	107	13

The amount of maleic hydrazide found in the tubers at harvest is shown in Table 5. It is evident that there was a considerable range in the amount of maleic hydrazide absorbed by the plants, and translocated to the tubers.

Specific gravity of tubers at harvest and at the end of the common storage period was not affected by treatment even though untreated tubers sprouted profusely (Table 6). This could be due to the fact that loss of water and the dry matter utilization for growth in the sprouting tubers held the ratio of dry matter to moisture relatively constant. Thus the specific gravity changes were negligible. However, when sprouting and root development occurred in soil storage (Table 1), specific gravity

TABLE 3.—*The effect of maleic hydrazide, as MH-30, applied by airplane on weight loss in common storage of fall-grown potatoes.*

Amount of maleic hydrazide applied	Per cent weight loss	
	1958-1959	1959-1960
3 pounds per acre	4.0	5.3
Untreated	5.8	11.8
6 pounds per acre	5.2	5.7
Untreated	6.1	11.9
L.S.D. 5%	0.6	1.0

TABLE 4.—*The effect of maleic hydrazide, as MH-30, applied by airplane on the total yield of fall-grown potatoes.*

Amount of maleic hydrazide applied	Yield in hundredweights per acre	
	1958-1959	1959-1960
3 pounds per acre	185	93
Untreated	187	109
6 pounds per acre	185	99
Untreated	193	113
L.S.D. 5%	n. s.	n. s..

TABLE 5.—*The maleic hydrazide content of fall-grown potatoes at harvest following airplane application of MH-30.*

Amount of maleic hydrazide applied	Parts per million of maleic hydrazide in tubers			
	1958-1959		1959-1960	
	Sample range	Average	Sample range	Average
3 pounds per acre	6 to 53	34	11 to 18	15
6 pounds per acre	34 to 88	60	12 to 65	38

TABLE 6.—*The effect of maleic hydrazide, as MH-30, applied by airplane on specific gravity of fall-grown potatoes before and after common storage.*

Amount of maleic hydrazide applied	Specific gravity			
	1958-1959		1959-1960	
	At harvest	At end of storage period	At harvest	At end of storage period
3 pounds per acre	1.072	1.071	1.075	1.077
Untreated	1.071	1.073	1.071	1.075
6 pounds per acre	1.070	1.073	1.073	1.077
Untreated	1.071	1.072	1.073	1.078
L.S.D. 5%	n. s.	n. s.	0.002	0.002

was lower in such tubers than in the tubers which had little sprouting, perhaps because of comparatively little moisture loss from the sprouting tubers.

SUMMARY

In Tulare County, California, airplane application of maleic hydrazide as MH-30 on fall grown potatoes retarded sprouting in field storage and in subsequent common storage. Weight loss in common storage was significantly reduced. Total yield was not significantly affected. Three pounds of maleic hydrazide per acre were generally as effective as were 6 pounds.

There was a wide range in the amount of maleic hydrazide residue found in the tubers at harvest. On the average, about twice as much maleic hydrazide was found in the tubers from plants treated with 6 pounds of maleic hydrazide per acre than was found in those from the 3-pound plots.

Specific gravity of tubers harvested on February 26, 1959 and on March 23, 1960, was not affected by treatment.

Preliminary results in 1957-58 showed that hand-sprayed maleic hydrazide prevented a reduction in specific gravity of soil-stored potatoes when harvest was delayed.

LITERATURE CITED

1. Timm, H. 1958. Potato sprout inhibitor spray. Cal. Agr. 12:6, 12.
2. Timm, H., J. C. Bishop, and B. J. Hoyle. 1959. Investigations with maleic hydrazide on potatoes. I. Effect of time of application and concentration upon potato performance. Am. Potato J. 36: 115-123.

VIRICIDAL DISINFESTANTS FOR THE POTATO CUTTING KNIFE[1]

L. C. PETERSON[2], R. L. PLAISTED[3] AND JAIME DIAZ[4]

The cutting-knife long has been suspected as an agent of virus transmission. That it is, has been confirmed experimentally with both the spindle-tuber virus (3) (5) and potato virus X (6) (7). The dramatic importance of bacterial diseases has stimulated considerable work on knife disinfestants, and agents for this purpose now are well known. Less attention has been paid to materials possessing viricidal properties. The problem is of specific importance to those concerned with the development of new varieties, for quantities of primary seed stocks are of such small dimensions, that a slight spread of virus early in the "life" of a selection may have serious consequences later. The object of this work was to find a knife disinfestant that is viricidal, readily available, and not cumbersome to use.

METHODS AND MATERIALS

Potato virus X was chosen as the test virus because, a uniform source of inoculum was available, the virus is known to be knife transmissible and a sensitive and easily usable "test-plant" was available, i.e. *Gomphrena globosa* L. (8).

The inoculum was prepared from ground sprouts and peelings of the variety Russet Rural. Distilled water was added to this material, making a mixture having a thick, soup-like consistency. Sterile cutting-knives were contaminated by immersing the blades in the inoculum. Infested knives immediately were placed in suspensions or solutions of the chemicals being tested as disinfestants.

Plants of *G. globosa* were prepared in the usual manner for mechanical inoculation with potato virus X. Plants were trimmed to 4-6 pairs of leaves and each leaf was considered as an experimental unit. Prior to inoculation *Gomphrena* plants were dusted with 400-mesh carborundum. Inoculations were made with the blades of treated knives. Where needed to facilitate inoculation, a drop of distilled water was added to the leaf. The inoculated plants were rinsed immediately with tap water. Ten days after inoculation, the number of local lesions produced were counted. The experimental plans employed varied; each will be described where used.

The same procedure was used when virus-free Katahdin tubers were substituted for *Gomphrena*. As each tuber was cut, the pieces were planted immediately. When the plants were twelve inches in height, they were treated for the presence of virus X.

EXPERIMENTAL RESULTS

Chemical screening tests

The effects of basic compounds and salts of heavy metals on the

[1]Accepted for publication March 4, 1961.

[2-3]Department of Plant Pathology and Plant Breeding, respectively, Cornell University, Ithaca, N. Y.

[4]Plant Pathologist, Servicio Cooperativo Interamericano de Agricultura, Quito, Ecuador.

protein molecule are well known. Trisodium phosphate, spray lime, ($Ca(OH)_2$), and mercuric chloride, chosen as representatives of these classes of compounds, were tested as possible knife disinfestants. Also included in the tests were sodium carbonate, bentonite clay, and Orthocide-50 (captan 50%); the last-named material is commonly used as a seed-piece disinfectant. Each contaminated knife was placed in the test chemical for 30 seconds and then used immediately for inoculation. One plant of *G. globosa*, trimmed to three pairs of leaves, was used for each chemical. One leaf of each pair was rubbed with a contaminated knife treated with distilled water and the other with an infested knife treated with a chemical.

All chemicals tested, with the exception of Orthocide-50, were found to be effective knife disinfestants (Table 1). Calcium hydroxide, trisodium phosphate, and bentonite clay consistently were the most effective. Mercuric chloride and sodium carbonate caused severe leaf damage to *Gomphrena* despite immediate washing.

When Katahdin potatoes were substituted for Gomphrena, 74% transmission was obtained when tubers were cut with contaminated knives and none when similar knives were treated with trisodium phosphate. The use of potatoes was discontinued in favor of the more usable *G. globosa*.

TABLE 1.—*The effectiveness of certain chemicals as disinfestants of cutting-knives contaminated with potato virus X, as measured by the number of local lesions produced on inoculated leaves of Gomphrena globosa.*

Chemical	pH	Formulation	No. lesions induced by infested knives treated as indicated[1]	
			Chemical treatment	Distilled water control
Mercuric chloride	5.00	1:1000	33	345
Mercuric chloride	5.31	1:2000	40	261
Bentonite Clay	8.70	Suspension	10	318
Sodium carbonate	8.98	Saturated	37	365
Trisodium phosphate	11.70	Saturated	6	171
Calcium hydroxide	12.37	Saturated	1	342
Orthocide-50	4.00	4 lbs/100	255	200
Tap Water	7.32		388	331

[1]Total number of lesions on 3 leaves.

Duration of treatment

This experiment was designed to determine the duration of knife exposure required to obtain maximum effect of the disinfestant. Calcium hydroxide and trisodium phosphate were used as the test materials and the duration of knife disinfestation ranged from an instantaneous dip to one of 60 seconds.

The experiment consisted of 12 treatments replicated 10 times. The experimental design employed was that described by Zoellner and Kempthorne (9) as an incomplete block design, with blocks of two plots, (reference 22). The entire experiment was repeated.

All chemical dip treatments were effective as knife disinfestants (Table 2). The calcium hydroxide treatments resulted in significantly fewer lesions on *Gomphrena* than did the trisodium phosphate treatments. Except for the instantaneous dip, the duration of knife exposure had little effect on the amount of transmission. Calcium hydroxide appears to be the better disinfestant, for its use consistently resulted in fewer lesions on inoculated leaves of *Gomphrena* than did the use of trisodium phosphate. Both compounds, especially trisodium phosphate, have a drying effect on the hands when used over prolonged periods.

Additional comparisons

A number of other materials were tested as possible disinfestants. Included among these were 70% ethyl alcohol, alcohol dip plus flaming, copper sulphate, bordeaux mixture (4-4-50), boiling water, and washing the knife blade in a rapidly flowing stream of water. All were found to be highly effective in disinfecting the cutting-knife, but none more so than calcium hydroxide.

Reversibility of inactivation by salts of heavy metals

The action of heavy metals on virus activity is caused by the precipitation of the protein. Should the metal be removed, the possibility exists that virus activity also may be restored. Mercuric chloride was chosen as the test chemical, and two types of expriments were conducted—one based on dialysis and the other on dilution. Only the dialysis experiment will be discussed since the results of both experiments were similar.

Two standard dilutions of infective sap and mercuric chloride were used 1) 5% infective sap in water and 0 mercuric chloride; and 2) 5% infective sap and 0.5% mercuric chloride. The preparations were allowed to stand for an hour and then divided in two parts—one half being placed in a cool area and the other half dialyzed for 5½ hours. *Gomphrena* plants were inoculated with both dialyzed and non-dialyzed preparations. The experimental design used consisted of 4 treatments, two incomplete blocks of two treatments each, all replicated 26 times.

The number of lesions on *Gomphrena* inoculated with mercuric chloride-treated infective sap after dialysis was significantly greater (12 x) than on those inoculated with similar sap not dialyzed. It is evident, however, that dialysis restored only a small part of the original virus activity.

Tuber protectants

It has been shown that transmission of virus X may occur from sprout to sprout when infected and noninfected tubers are stored in the same bag (2). Likewise, spindle-tuber virus is known to spread from the cut surfaces of diseased to adjacent healthy seed (4) (5).

In preliminary experiments it was found that virus transmission occurred when freshly cut surfaces of seed infected with potato virus X were used to inoculate leaves of *Gomphrena*. When such seed was liberally dusted with lime or bentonite clay prior to their use in inoculating *G. globosa*, no virus transmission resulted. In a like manner, virus-infected debris collected from the seed-wheel of an assist-feed potato planter produced local lesions when used to inoculate leaves of *Gomphrena*. No

TABLE 2.—*Number of local lesions produced by potato virus X on leaves of Gomphrena globosa rubbed with contaminated cutting-knives dipped in trisodium phosphate or calcium hydroxide for different periods of time.*

Chemical	Time of treatment (Seconds)	Total number of lesions per treatment[1]
None	–	408
Water	–	539
Trisodium	(Instantaneous)	48
	15	31
	30	24
	45	25
	60	30
Calcium hydroxide	(Instantaneous)	46
	15	0
	30	3
	45	3
	60	4

[1]Total number of lesions on 10 leaves.

TABLE 3.—*Relative infectivity of potato virus X in infective sap mixed with mercuric chloride and dialized before inoculation to Gomphrena globosa.*

Dilution of infective sap	Mercuric chloride (%)	Preparation tested	
		Treatment	No. of lesions per treatment[2]
1:20	0	None	1629
1:20	0	Dialized[1]	1682
1:20	.5	None	14
1:20	.5	Dialized	178

[1]Dialysis was for 5½ hours, beginning 1 hour after mixing.
[2]Total number of lesions on 26 leaves.

virus transmission occurred if the wheel was thoroughly covered with either lime or bentonite clay. When used on seed, lime has a drying effect which is intensified and may become serious if treated seed is stored at high temperatures for long periods.

DISCUSSION

Erratic results are often obtained in attempts to transmit viruses to tubers by means of the cutting-knife. A high percentage of transmission occurs in some tests and little or none in others conducted under apparently similar conditions. The substitution of *G. globosa* for potatoes as the "test-plant" for virus X, permitted a more rapid and accurate assessment of the chemicals being tested as viricides than would have been otherwise possible. The exteme sensitivity of *Gomphrena* to virus X might result in elimination of some chemicals that may be of value under

practical working conditions. However, those chemicals which passed the "*Gomphrena* test" are certain to be completely effective in preventing transmission to potatoes.

Since plant viruses as a group are inactivated rapidly in solutions more alkaline than pH 10-11 (1) (10) the materials found effective for virus X should be just as effective for spindle-tuber virus or any other knife transmissible virus.

Loss in viricidal activity from dilution caused by continued use of the solution, is not a factor with such materials as calcium hydroxide. Stock suspensions or solutions can be prepared with an excess of lime, which will maintain the original pH and a constant viricidal activity. The use of cutting-knives in rotation assures their exposure to the disinfestant for its maximum effectiveness without causing any delay in the cutting operation. Calcium hydroxide seems to fulfill the requirements for a good viricidal knife disinfestant; it is readily available, inexpensive, and not cumbersome to use, is not excessively corrosive, and possesses good viricidal properties.

That calcium hydroxide is not effective as a knife disinfestant for ring rot is illustrated by the following experience. A commercial lot of 100 tubers was being indexed, using seven knives in rotation which were immersed in a suspension of lime. One tuber was systemically infected with ring rot as shown by appearance of symptoms in both vines and tuber. One other index plant showed ring rot symptoms. This was from the seventh cut following the systemically invaded tuber. The conclusion is drawn that the bacteria were retained in the cutting knife in the lime suspension for the length of time for one rotation, estimated at approximately five minutes. There is no evidence either for or against the possibility that ring rot bacteria might persist for more than one rotation or might become dispersed in the suspension and cause other infections. The question is raised whether a compatible chemical such as copper sulphate might not be added to the lime suspension which would also make it effective against bacterial and fungus pathogens.

Although dilution or dialysis, partially reversed the effect of mercuric chloride on the virus, it is doubtful that the extent of virus recovery would be of any significance in a practical seed-cutting operation. The value of compounds such as mercuric chloride, copper sulphate, or bordeaux mixture lies in their combined properties—bactericidal, fungicidal, and viricidal.

Summary

Thirty-second dip in calcium hydroxide, trisodium phosphate, or bentonite clay were effective in preventing knife transmission of potato virus X. Slightly less effective were mercuric chloride and sodium carbonate.

Calcium hydroxide was slightly superior to trisodium phosphate as a knife disinfestant for virus X.

Seventy per cent ethyl alcohol, alcohol plus flaming, copper sulphate, bordeaux mixture (4-4-50), boiling water, and washing the knife blade in a rapidly flowing stream of water also proved effective but none exceeded the effectiveness of calcium hydroxide.

Increasing the period of knife exposure from 15 to 60 seconds has little effect on the viricidal properties of the disinfestants.

Only slight virus activity was restored when infective sap treated with mercuric chloride was dialized for a period of 5½ hours.

Literature Cited

1. Bawden, F. C. and N. W. Pirie. 1938. Plant viruses I Serological chemical and physico-chemical properties. Tabulae Biologicae 6: 355-371.
2. Bawden, F. C., B. Kassanis and F. M. Roberts. 1948. Studies on the importance and control of potato virus X. Ann. Appl. Biol. 35: 250-265.
3. Bonde, R. 1927. The spread of spindle tuber by the knife. Am. Potato J. 4: 51-52.
4. Bonde, R. and D. Merriam. 1951. Studies on the dissemination of potato spindle tuber virus. Am. Potato J. 28: 558-560.
5. Goss, R. W. 1926. Transmission of potato spindle-tuber by cutting knives and seed piece contact. Phytopathology 16: 299-304.
6. Larson, R. H. 1950. The spread of ring-spot virus X by cutting knife. Am. Potato J. 27: 53-54.
7. Mai, W. F. 1947. Virus X in the newer potato varieties and transmission of this virus by the cutting knife. Am. Potato J. 24: 341-351.
8. Wilkinson, R. E. and F. M. Blodgett. 1948. *Gomphrena globosa* a useful plant for qualitative and quantitative work with potato virus X (Abs.) Phytopathology 38: 28.
9. Zoellner, J. A. and O. Kempthorne. 1954. Incomplete block designs with blocks of two plots. Iowa Agr. Exp. Sta. Res. Bull. 418: 171-180.
10. Smith, K. M. 1951. Recent advances in the study of plant viruses. 2nd Ed. The Blakiston Co. 300 p.

CHEMICAL CONTROL OF POTATO SEED PIECE DECAY[1]

ROLAND F. LINE AND CARL J. EIDE[2]

INTRODUCTION

The use of chemical protectants to control seed piece decay of potatoes in Minnesota has often failed to improve stands or increase yields; therefore, seed treatment is not generally recommended. However, according to Hoyman (2) 35% of the potato acreage in Minnesota is planted with treated seed pieces. Several of the chemical protectants used by potato growers in Minnesota as well as some relatively new ones were tested in 1957 and 1958. Tests were made in the laboratory to determine the toxic effect of the materials on known seed piece decaying organisms and in the field to determine their effect on emergence and yield from non-inoculated seed pieces and seed pieces inoculated with bacteria and fungi.

Except as noted later, isolates of *Fusarium* spp. and *Erwinia* spp. were used as inoculum in both field and laboratory tests. Two groups of isolates identified according to Snyder and Hansen's classification (4, 5) as *Fusarium oxysporum* Schl. and *F. roseum* Lk. were used because of their difference in decay-producing ability, *F. roseum* causing more damage than *F. oxysporum*. Tests were made with three isolates of each of these two species, plus two of *Erwinia carotovora* (Jones) Holland and two of *E. atroseptica* (Van Hall) Jennison.

RESULTS

Field Tests

In 1957 freshly cut, uniform Irish Cobbler seed pieces were placed on screens and sprayed uniformly with inoculum of two isolates each of *F. oxysporum, F. roseum, E. carotovora,* and *E. atroseptica.* The spore and bacterial suspensions were washed with distilled water from 5-day old cultures on potato dextrose agar in petri plates and maintained at 2 to 4 C to reduce spore germination or cell division until the inoculum was sprayed onto the seed pieces. The inoculated seed pieces were air dried for 5 minutes and then dipped into a water suspension of the chemical protectant for one minute or dusted with the chemical mixed with pyrax to form the desired percentage of active ingredient. Excess dust was shaken off the seed pieces. The treated seed was air dried, put into cotton bags which were put into individual polyethylene bags, stored for 3 days at 21 - 27 C and planted in the field in a randomized block design.

The materials and methods used in two experiments in 1958 were similar to those used in 1957 except for the following changes. In the first test a lot of non-inoculated seed pieces was included and the bacterial inoculum consisted of soft-rotted tissue washed with distilled water from

[1]Accepted for publication April 27, 1961. Paper No. 4608, Scientific Journal Series, Minn. Agr. Exp. Sta., St. Paul, Minnesota.

[2]Department of Plant Pathology and Botany, University of Minnesota, St. Paul, Minnesota.

infected tubers. Fusarium spores were grown on agar as in 1957. In a second test in 1958 Captan 50W was compared with no treatment when seed pieces were sprayed with i) *F. oxysporum;* ii) *F. roseum;* iii) a mixture of i) and ii); iv) soft-rotted potato tissue; v) a mixture of i), ii), and iv); and vi) distilled water. Both plots in 1958 were planted in a split randomized block design.

In 1957, of 25 treatments tested on seed pieces inoculated with Fusarium and bacteria and planted in the field, all but acid mercury and 2 wax products improved stands and increased yields. This is shown in Table 1.

In 1958 a test comparing 17 treatments on seed inoculated with a mixture of *Fusarium* spp. and soft-rotted potato tissue and on non-inoculated seed showed (Table 2) that neither acid mercury nor Agrimycin increased emergence or yield. Nor was there any increase in emergence or yield when Captan 50W dust or a combination of Captan 50W plus Agrimycin as a dip, were applied to inoculated seed.

When either of the latter two materials or Zineb plus Agrimycin were used on non-inoculated seed, both yields and emergence were greater than when they were applied to inoculated seed. This may indicate that these were more effective against organisms naturally present on the tubers than against those applied as inoculum. However, the differences in yield from inoculated and non-inoculated seed were not statistically significant when treated with the other 14 materials. The same generalizations were true of emergence except that Zineb dip and Captan 50WBU dust were more effective on inoculated than on non-inoculated seed.

The possibility that the effectiveness of a chemical treatment depends on the organisms present was tested and the results are presented in Table 3. The different combinations of inoculum appear in the table. The inoculated seed was treated with Captan 50W dip and then held three days at 21 to 27 C as in the other tests. Both emergence and yield were improved tremendously by the Captan 50W. The organisms used for inoculation made no statistically significant difference in yield. However there were significant differences in the emergence from the treated seed inoculated with the different combinations of organisms. A mixture of the three appeared most difficult to control, and all seed pieces inoculated with soft-rotted tissue produced plants when treated. It is apparent that the two species of *Fusarium* were more destructive and difficult to control than the organisms in the soft-rotted tissue, which actually seemed to protect the non-treated seed. This is indicated by an emergence of 20.8% whereas that from the non-inoculated seed was only 2.5%.

Laboratory Tests

The lack of effectivenesss of certain materials (Tables 1 and 2) might be because they are not sufficiently toxic to the decay organisms or because they are absorbed or inactivated by the potato tissue. Experiments were made in the laboratory to test these hypotheses.

Agar in petri dishes was seeded with Fusarium spores or bacteria of the species used in the field tests. The method was similar to that used by Thornberry (6) and by Loo, et al (3) for assaying chemicals. Twenty ml of potato dextrose agar was poured into 9-cm petri plates.

TABLE 1.—*Per cent emergence and yield from potato seed-pieces treated with chemical protectants after inoculation with a mixture of Fusarium and Erwinia spp., Agricultural Experiment Station at Rosemount, 1957.*

Teatment and rate		Yield[1] lbs.	Emergence[2] pct.
Captan 50W	1 lb/10 gal	16 [3]	86 [3]
	1 lb/15 gal	17	92
	1 lb/20 gal	18	86
	7.5% dust	20	93
	15.0% dust	19	92
Captan 50WKBU	1 lb/10 gal	21	93
	1 lb/15 gal	16	69
	1 lb/20 gal	21	98
	7.5% dust	20	92
	15.0% dust	21	93
Captan 50WKBN	1 lb/10 gal	20	92
	1 lb/15 gal	21	98
	1 lb/20 gal	16	86
	7.5% dust	21	92
	15.0% dust	19	96
Maneb 1 lb/10 gal		19	98
7.5% dust		17	92
Zineb 7.5% dust		19	83
Streptomycin sulfate 100 ppm		17	92
Streptomycin sulfate 100 ppm plus Captan 50W 1 lb/15 gal		16	83
Agrimycin[4] 200 ppm plus Zineb 5.0% dust		21	94
Acid mercury 6.8 $HgCl_2$/40 ml HCl/1 gal water		8	3
Johnson's Wax	D119 dip	8	3
	D3 dip	6	2
Unteated check		3	1

[1]Yield is the mean of six 12-hill rows.
[2]Per cent emergence is based on six 12-hill rows.
[3]Figures bracketed are not significantly different statistically at the 5% level; multiple range test.
[4]Agrimycin is a trade name for a mixture containing 15% streptomycin and 1.5% oxytetracycline plus ineret ingredients.

Five ml of melted agar (40 C) containing *Fusarium* spores or bacteria washed from 5-day-old cultures growing on potato dextrose agar in petri plates was poured on top of the solidified 20 ml of agar. Immediately after the 5 ml of agar had solidified, filter paper discs or potato discs treated with the chemical protectants were placed on the seeded agar.

TABLE 2.—*Yield and emergence of Irish Cobbler potatoes from seed pieces treated with chemical protectants. Agricultural Experiment Station at Rosemount, 1958.*

	Inoculated[2]	Yield[3] lbs.	[4]	Emergence[3] pct.	[5]
Captan 50W dip	+	15.1		98	
Captan 50W dust	0	*14.8		*92	
Captan 50Wdip	0	14.7		96	
Zineb + Agrimycin dip	0	*14.2		*93	
Captan 50WKBN dip	0	14.0		90	
Captan 50WKBN dip	0	13.5		81	
Maneb dust	0	13.0		98	
Maneb + Agrimycin dip	+	12.9		96	
Captan 50WKBN dip	+	12.8		93	
Maneb dust	+	12.6		89	
Maneb + Agrimycin dip	0	12.2		98	
Captan 50W + Agrimycin dip	0	*11.8		*77	
Zineb dip	+	11.8		*83	
Captan 50WKBU dust	+	11.5		*96	
Captan 50WKBU dip	+	11.3		78	
Zineb dust	+	11.3		78	
Captan 50 WKBN dust	+	11.2		98	
Zineb dust	0	10.7		75	
Maneb dip	+	10.7		79	
Captan 50 WKBN dust	0	10.3		98	
Zineb + Agrimycin dip	+	9.0		64	
Captan 50 WKBU dust	0	8.8		65	
Zineb dip	0	8.1		42	
Maneb dip	0	7.2		54	
Captan 50W + Agrimycin dip	+	4.2		44	
Captan 50W dust	+	3.6		23	
Acid mercury dip	+	2.4		23	
Acid mercury dip	0	2.3		38	
Agrimycin dip	+	1.3		14	
Agrimycin dust	0	1.0		2	
Check	+	0.8		8	
Check	0	0.4		0	
Agrimycin dip	0	0.0		0	
Agrimycin dust	+	0.0		2	

[1]Dust treatments consisted of 15% active ingredients mixed with pyrax. Dip treatments consisted of 1 lb per 10 gal of water for all materials but agrimycin (100 ppm) and acid mercury (6 oz. $HgCl_2$/40 ml. HCl/1 gal. H_2O).

[2]+ indicates inoculaltion with fungi and bacteria before treatment; 0 = no inoculation.

[3]Per cent emergence and yield are based on six 12-hill rows.

[4]Figures bracketed are not significantly different statistically at the 5% level, multiple range test. Asterisks indicate that the emergence or yield was significantly higher than those of the corresponding inoculated or non-inoculated lots treated with the same materials.

[5]Three groups of emergence figures differing significantly are shown. There is some overlapping between these groups, but this could not be indicated conveniently since the materials are not arranged in order of decreasing emergence.

TABLE 3.—*Emergence and yields of Irish Cobbler potatoes from seed inoculated with several combinations of pathogens and dipped in Captan, Agricultural Experiment Station at Rosemount, 1958.*

	Treatment	Yield[2] lbs.	Emergence[3] pct.
F. oxysporum, F. roseum, & soft rotted potato tissue	0	0.0 [4]	0.0 [4]
F. roseum	0	0.0	1.7
None	0	0.0	2.5
F. oxysporum & *F. roseum*	0	0.8	5.8
F. oxysporum	0	1.8	6.7
Soft rotted potato tissue	0	3.1	20.8
F. oxysporum, F. roseum, & soft rotted potato tissue	captan[1]	11.1	76.7
F. oxysporum & *F. roseum*	captan[1]	11.2	83.3
F. oxysporum	captan[1]	10.1	85.3
F. roseum	captan[1]	10.7	89.2
None	captan[1]	12.7	95.8
Soft rotted potato tissue	captan[1]	10.7	100.0

[1]Captan, 1 lb/10 gal of water.

[2]Yield is the mean of six 12-hill rows.

[3]Per cent emergence is based on six 12-hill rows.

[4]Figures bracketed are not significantly different statistically at the 5% level, multiple range test.

The chemicals, with the exception of Agrimycin and acid mercury, were applied to filter paper discs by dipping 9 cm discs of the paper into a water suspension of 10 gm of chemical in 1000 ml of water. The paper was dried, cut into 1.4 cm discs, and placed on the seeded agar. Agrimycin was applied similarly as a suspension of one g in 1000 ml of water and acid mercury was applied by dipping 1.4 cm discs into a solution of 6.8 g $HgCl_2$, 40 ml of concentrated HCl and one gallon of water. Immediately after dipping, the acid mercury-treated discs were placed on seeded agar.

To prepare the potato discs, tubers were washed, cut into seed pieces, dipped for 1 minute into a suspension of chemical protectants at the same concentration used for the filter paper treatment, and air dried. Discs 1.4 cm in diameter and 3 mm thick were removed from the cut surface of the treated seed pieces and placed on the seeded agar with the treated surface of the discs in contact with the seeded agar.

After 24 to 48 hours a clear inhibition zone surrounded some of

the paper or potato discs. The diameter of the zone was used as a measure of the effectiveness of the chemicals.

Table 4 shows the effects of chemical protectants on the germination of *Fusarium* spores. Captan 50W, Captan 50 WKBU, Captan 50 WKBN, Captan 50W plus Agrimycin, maneb, zineb, and acid mercury inhibited spore germination when applied with filter paper discs, but zineb was less effective than the others. When tested on potato discs zineb did not inhibit spore germination, and the effectiveness of the other chemicals was less than when applied on paper discs. Agrimycin did not inhibit the fungi. Except for acid mercury, the chemicals generally inhibited *F. roseum* less than they did *F. oxysporum*. Inhibition of germination by acid mercury was the same for both Fusarium species.

Agrimycin, Captan 50W, Captan 50 WKBU, Captan 50 WKBN, Captan 50W plus Agrimycin, acid mercury and maneb inhibited growth of bacteria on agar when the chemicals were applied on filter paper discs. (See Table 5). Of the above chemicals, maneb was not effective when applied on potato discs but the rest were. Zineb-treated paper and potato discs did not inhibit the bacteria.

The differences in the apparent effectiveness of the chemicals when

TABLE 4.—*Diameter of the inhibition zones surrounding chemically-treated discs on potato dextrose agar seeded with Fusarium spores.*

Treatment		*Fusarium oxysporum*		*Fusarium roseum*	
		Paper discs	Potato discs	Paper discs	Potato discs
		cm.	cm.	cm.	cm.
Captan 50W	Mean[1]	3.1	2.5	2.3	1.8
	Range	2.8-3.3	2.3-3.3	2.2-2.4	1.7-2.1
Captan 50WKBU	Mean	3.2	2.6	2.3	1.9
	Range	2.8-3.5	2.5-3.3	2.2-2.4	1.8-2.3
Captan 50WKBN	Mean	3.2	2.6	2.3	1.9
	Range	2.8-3.5	2.4-2.9	2.2-2.5	1.9-2.0
Maneb	Mean	3.9	2.3	2.3	Trace
	Range	3.5-4.0	1.4-3.0	2.1-2.5	0.0-1.5
Zineb	Mean	2.5	0.0	Trace	0.0
	Range	2.0-2.7		0.0-1.6	
Agrimycin	Mean	0.0	0.0	0.0	0.0
Captan 50W plus Agrimycin	Mean	3.2	2.4	2.4	1.8
	Range	2.8-3.5	1.8-2.5	2.3-2.4	1.5-2.2
Acid mercury	Mean	2.9	2.3	2.9	2.1
	Range	2.7-3.3	1.9-3.0	2.5-3.0	1.9-2.8
Untreated check	Mean	0.0	0.0	0.0	0.0

[1]The mean diameter of the inhibition zone is based on three isolates of each Fusarium species and five replications.

applied on paper or potato discs may have been due to differences in dosage, because the exact amounts of the chemicals on the different discs was not determined. Nevertheless, it appears that none of the materials was greatly inactivated by the potato tissue, except possibly zineb.

TABLE 5.—*Diameter of the growth inhibition zones surrounding chemically-treated discs on potato dextrose agar seeded with Erwinia carotovora and E. atroseptica.*

Treatment		Paper discs	Potato discs
		cm.	cm.
Captan 50W	Mean[1]	2.0	1.6
		1.8-2.2	1.5-1.6
Captan 50WKBU	Mean	2.1	1.6
	Range	1.9-2.5	1.6-1.9
Captan 50WKBN	Mean	2.0	1.6
	Range	1.9-2.1	1.4-1.6
Maneb	Mean	1.7	0.0
	Range	1.6-1.7	
Zineb	Mean	0.0	0.0
Agrimycin	Mean	1.9	1.5
	Range	1.7-2.0	1.4-1.5
Captan 50W plus Agrimycin	Mean	2.1	1.6
	Range	1.9-2.8	1.6-1.7
Acid mercury	Mean	3.0	2.3
	Range	3.0-3.5	2.0-3.7
Untreated check	Mean	0.0	0.0

[1]The mean diameter of the inhibition area is based on two isolates of each species and five replications.

CONCLUSIONS

A number of different chemicals protect cut potato seed from decay which starts if cut seed is stored under unfavorable conditions. Emergence and yielding ability are protected to about the same degree.

Fungicidal and bactericidal potency in culture do not necessarily indicate field behavior of a chemical. Neither does inactivation of chemical protectants by potato tissue seem likely to affect their effectiveness in practice. It seems more probable that injury to the potato tissue increases its susceptibility to decay, possibly by reducing the rate and extent to which the wound protective layer is formed, as suggested by Bonde and Hyland (1) for Agrimycin. The experience of many potato growers has shown that acid mercury may also injure cut seed pieces.

Tubers generally carry enough inoculum of decay organisms to damage or destroy seed pieces stored at 20 to 30 C with poor ventilation. Further inoculation under such conditions did not increase decay, although

there were indications that certain protectants were more effective against the natural than against the artificial inoculum. A further complication due to antibiosis between decay organisms is indicated by the apparent improvement of emergence by dipping seed pieces in a suspension of decayed potato tissue.

Summary

Laboratory and field tests in 1957 and 1958 indicate that some chemical protectants are toxic to decay-producing organisms and that some improved stands and yields from potato seed pieces which were stored before planting. Some of the commonly used chemical protectants such as certain antibiotics and acid mercury were not effective against seed piece decay under the conditions of the tests. Decay-producing organisms apparently are present on most potato tubers making artificial inoculation superfluous.

Literature Cited

1. Bonde, Reiner, and Fay Hyland. 1960. Effects of antibiotics and fungicidal treatments on wound periderm formation, plant emergence, and yields produced by cut seed potatoes. Am. Potato J. 37: 279-288.
2. Hoyman, W. G. 1957. Potato seed treatment. Potato Handbook; Disease control, Vol. 2: 13-17. Potato Ass'n. of America, New Brunswick, N. J..
3. Loo, Y. H., P. S. Skell, H. H. Thornberry, J. Ehrlich, J. M. McGuire, G. M. Savage, and J. C. Sylvester. 1945. Assay of streptomycin by the paper-disc plate method. J. Bact. 50: 701-709.
4. Snyder, W. C., and H. N. Hansen. 1940. The species concept in *Fusarium* Am. J. Bot. 27: 64-67.
5. Snyder, W. C., and H. N. Hansen. 1945. The species concept in *Fusarium* with reference to discolor and other sections. Am. J. Bot. 32: 657-666.
6. Thornberry, H. H. 1950. A paper disc plate method for the quantitative evaluation of fungicides and bactericides. Phytopathology 40: 419-429.

CHIPPING TESTS OF POTATO VARIETIES AND SELECTIONS GROWN IN NORTH DAKOTA[1]

R. H. JOHANSEN AND J. C. HANSEN[2]

INTRODUCTOON

The per capita consumption of potato chips in the United States has increased from 2.8 pounds in 1950 to 6.7 pounds inn 1960. From about 4.5 million bushels in 1940, the industry has expanded and now processes about 60 million bushels into potato chips, with the Red River Valley of North Dakota and Minnesota supplying a good share of them.

An estimated 11% of the Red River Valley potato crop was processed into potato chips in 1959. These potatoes are either chipped by manufacturers located in North Dakota and Minnesota or shipped as a raw product to centralized chipping plants located in various parts of the United States and Canada. The prospects appear bright for continued expansion of the chip industry, which means that new and improved chipping varieties will be in constant demand by potato chip manufacturers.

The most common varieties grown in the Red River Valley for chipping are the Kennebec and Irish Cobbler. Both of these varieties produce chips of acceptable quality; however, they have not been ideal in every sense.

A new chipping variety must have several desirable qualities before it is accepted by the potato chip industry, with certain qualities being slightly superior to that of the present variety used by the potato chip manufacturer.

Probably one of the most important requirements of a good chipping variety is that it must produce chips of light-brown salable color. Smith and Talburt (5) reported that control of color, which is necessary for a standard product, is difficult because the color of the potato chip is determined by the chemical composition of the potato tuber. According to Smith and Talburt (5); Smith (6,7); Shallenberger and Smith (3); Schwimmer, et al (4), the darkening of potato chips following frying is associated with reducing sugars, mainly glucose, fructose, and xylose, with possible combinations of certain amino acids. Shallenberger and Smith (3) found no obvious correlation existing between chip color and any single component except total sugars and reducing sugars. When potatoes are stored at temperatures of 40 F or less, an appreciable amount of these sugars build up, causing the chips to be a dark brown unsalable color. Desired chipping varieties have the ability to reduce these constituents, or de-sugar when stored at 70 F for several weeks, and henceforth produce chips of light brown color. Watada and Kunkel (8) found a wide variation in reducing sugar content of potato varieties in storage, and that these varieties differed greatly in the reconversion of their reducing sugars back to starch. According to Findlen (2), the use of fertilizers in the Red River Valley had no important effect on chip color.

Specific gravity is another important characteristic of a good chipping variety. A variety with high specific gravity gives a high yleld of chips

[1]Accepted for publication March 17, 1961.
[2]Horticultural Department, North Dakota State University, Fargo North Dakota.

and a low oil absorption. According to Smith and Talburt (5), varieties with high oil absorption are too costly to the chip manufacturer in retaining the oil used in frying, and produce a soggy, oily chip. Potato chips should be crisp and have an appetizing flavor. Although specific gravity is considered to be a definite genetic characteristic, certain factors like culture, soil, and environment play an important role in effecting the specific gravity of the potato tuber. Akeley et al (1) found the highest specific gravity for the earliest date of planting. Findlen (2) reported that the use of very high rates of nitrogen fertilizer in the Red River Valley reduced the chip yield slightly.

Although not quite as important as chip color and yield, the type and shape of the potato tubers are also important in maintaining good chipping quality. Varieties that are smooth and shallow-eyed result in less peeling loss to the potato chip manufacture. A good chipping variety should possess all the desired horticultural characteristics sought in a good table or seed stock variety.

Materials and Methods

From 1957 through 1959, an attempt was made to evaluate most new varieties and selections for chipping quality. The potatoes used in the chipping experiment were grown in replicated variety trials at Grand Forks, Park River, and Williston, North Dakota. Park River and Grand Forks are located in the Red River Valley, while Williston is located in western North Dakota. The trials at Williston consisted of potatoes grown under irrigation and under dryland conditions. These trials were generally planted during the middle of May and harvested the third week in September.

At harvest time, a sample of each variety or selection was saved for chipping tests. These samples were stored in a potato cellar at 38 to 42 F in 1957-58 and at a contolled temperature of 40 F in 1959. The samples stored in the potato cellar from November to the middle of January were removed for immediate chipping and for reconditioning at room temperatures (60-70 F) until the final chip test. In 1959, a temperature-controlled unit enabled the chipping samples to be stored at 40 F from November to January, and then at 70 degrees until the chipping tests were completed in early March. The purpose of storing the potatoes at a controlled temperature was to study more accurately the reconditioning quality of several varieties and selections. According to Wright and Whiteman (9), one of the most important factors in the suitability of potatoes for chipping is their inherent capacity to recover rapidly from the effects of prolonged low-temperature storage. It is known that several varieties have the ability to recondition or de-sugar rapidly and produce chips of light color. After all samples were stored at reconditioning temperatures, they were chipped at intervals of one or two weeks for approximately two months.

For each chipping test, three to four tubers were peeled by an abrasive-type vegetable peeler. Following peeling, the tubers were sliced to approximately one-sixteenth inch thickness by a vegetable slicer and a composite sample of 100 grams secured for the chipping tests. These samples were washed in cold tap water to remove any free starch and then dried with paper toweling. Following thorough drying, these samples

were fried in peanut oil at 345 F until all bubbling ceased. After frying, the samples were again weighed and the color of the chips determined by the use of an arbitrary visual color chart (Fig. 1) of 1-6, with 1 being very dark brown and 6 very light brown. Chip color ratings of 3.5 and above were considered as salable chips. Chip yield was calculated as per cent of recoverable peeled-raw-sliced potato weight.

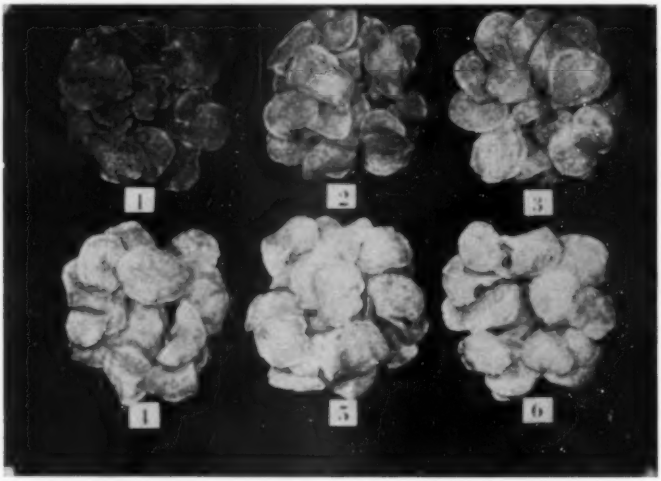

FIG. 1.—Arbitrary visual color chart used to determine chip color. Chip color of 3.5 and above was considered a salable chip.

RESULTS AND DISCUSSION

Chipping tests of potatoes grown at Park River and Grand Forks, North Dakota

Many numbered selections and varieties were tested for chipping quality. However, only the data from varieties and selections showing good commercial promise are included in this report.

The chip color of varieties and selections varied between the years 1957-59 and between the two locations at Park River and Grand Forks (Fig. 2) (Table 1 and 2). The color of the chips produced in 1957 was lighter than that of the chips produced in 1958 and 1959. The color of the chips produced in 1958 and 1959 was somewhat similar. The potatoes grown at Park River generally yielded chips of lighter color than did potatoes grown at Grand Forks (Fig. 2). It has been shown by Smith (7) that environmental conditions, such as maturity, moisture, and temperature have a marked effect on the color and quality of potato chips. Undoubtedly, the amount of rainfall and mean temperature influenced chip color at these two locations in the different years. Soil type in relation to soil moisture and temperature may have also influenced chip color. The soil type at Park River is Glyndon silt loam, which is considered to be

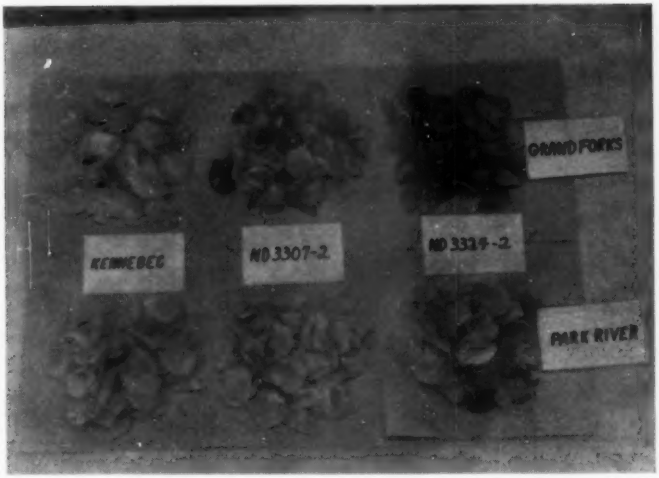

FIG. 2.—Chip color of 2 selections and one variety grown at Grand Forks and Park River, North Dakota. Note chip color at Park River was a much lighter brown.

quite course textured; while the soil type at Grand Forks is Bearden clay loam, a finer textured soil. Along with the moderately cool seasons and ample moisture, particularly in 1957 and 1959, the lighter, better-drained soils at Park River offered conditions more favorable for lighter and better chip color.

After reconditioning for six weeks, all varieties and selections improved in chip color, but not all varieties and selections produced salable chips. Some varieties inherently accumulate reducing sugars and other chemical constituents and show little or no de-sugaring after a period of reconditioning. The varieties Irish Cobbler and Kennebec were quite consistent in producing light colored chips after a period of reconditioning (Fig. 3). The selection ND 3324-2, particularly at Grand Forks, produced chips quite dark in color out of cold storage and after two weeks of reconditioning, but generally produced chips of light color after reconditioning for four weeks or longer. Although ND 3324-2 required a slightly longer period of reconditioning than Irish Cobbler and Kennebec, other characteristics make it a good chipping variety. When comparing this selection with Irish Cobbler and Kennebec, ND 3324-2 is superior to Irish Cobbler in shape and type and is higher in specific gravity than Kennebec. In maturity ND 3324-2 is comparable to Irish Cobbler, but is much earlier than Kennebec. ND 3324-2 is considered to be quite slow in breaking dormancy, which would be another advantage as a chipping variety. In 1959, ND 4122-2 made chips of light color when grown at Park River, but quite dark color when grown at Grand Forks. During 1957, the variety Norland made a light colored chip after most reconditioning periods, but in 1958 and 1959 chipped dark to medium dark after reconditioning. This again shows the importance of environment in influencing chip color.

TABLE 1.—*Chipping quality of varieties and selections grown at Grand Forks, North Dakota, 1957-1959.*

	Color[1] out of cold storage		Reconditioning periods												Average yield[2]		
			Color 2 weeks			Color 4 weeks			Color 6 weeks			Color 8 weeks					
	1958	1959	1957	1958	1959	1957	1958	1959	1957	1958	1959	1957	1958	1959	1957	1958	1959
															%	%	%
Irish Cobbler	2.0	1.3	4.5	3.3	1.8	4.5	4.5	2.3	5.9	..	3.9	5.1	..	4.0	33.7	34.8	31.2
Kennebec	1.8	3.4	4.5	3.0	3.5	6.0	3.6	5.0	4.7	..	5.1	5.3	..	5.8	30.7	34.9	32.1
Nordak	1.5	1.4	3.5	1.2	1.4	5.0	3.7	1.9	4.7	..	2.3	4.9	..	2.5	31.4	32.9	32.4
Norgleam	1.3	2.2	3.3	3.0	2.0	4.5	2.6	2.6	4.6	..	3.0	4.5	..	3.0	31.2	32.5	32.9
Norland	1.0	1.8	2.5	1.1	1.3	5.3	2.5	2.2	4.5	..	2.8	4.7	..	3.1	29.7	30.8	30.0
ND 3324-2	1.0	2.8	1.0	2.2	2.6	2.0	2.5	3.5	3.5	..	4.7	4.3	..	4.6	30.7	33.4	33.0
ND 4122-2	2.7	1.5	..	2.6	1.8	..	3.2	2.8	..	..	2.8	..	..	3.2	..	33.2	32.5
ND 4121-25	1.2	1.5	..	2.1	1.0	..	2.6	2.7	..	..	2.3	..	..	2.9	..	32.7	33.1
ND 3676-20	..	1.0	2.0	..	1.0	2.0	..	1.5	3.1	..	2.0	2.4	..	2.0	33.9	..	33.9
ND 3740-11	1.0	1.0	..	2.5	1.8	..	2.3	2.6	..	..	3.6	..	..	3.5	..	32.7	30.8
ND 3694-6	2.5	3.7	..	3.6	4.2	..	5.2	5.0	..	..	4.4	..	..	5.8	..	34.4	33.3
F29-1	1.0	1.0	..	1.0	1.0	..	1.3	1.8	..	..	2.3	..	..	1.6	..	31.3	30.5
Average	1.5	1.9	3.0	2.3	2.0	4.2	3.1	2.8	4.4	..	3.3	4.5	..	3.5	31.6	33.1	32.1

[1]Chip color (1-6) 1 dark brown, 6 light brown. Ratings of 3.5 and above are considered salable.
[2]Per cent based on 100 pounds of potatoes (average of several tests).

TABLE 2.—*Chipping quality of varieties and selections grown at Park River, North Dakota, 1957-1959.*

	Color[1] out of cold storage		Reconditioning periods												Average yield[2]		
			Color 2 weeks			Color 4 weeks			Color 6 weeks			Color 8 weeks					
	1958	1959	1957	1958	1959	1957	1958	1959	1957	1958	1959	1957	1958	1959	1957	1958	1959
															%	%	%
Irish Cobbler	1.7	3.5	3.5	3.5	3.9	5.3	4.7	4.7	6.0		4.7	5.9		5.0	34.4	35.1	33.8
Kennebec	1.2	3.4	6.0	4.7	5.6	6.0	5.4	5.5	6.0		6.0	5.9		5.9	32.1	32.9	32.5
Nordak	2.5	2.7	4.3	2.7	4.0	5.0	4.0	3.7	5.1		4.5	5.5		4.5	32.2	32.6	32.0
Norgleam	2.0	5.9	4.0	2.5	5.4	5.5	4.0	4.5	5.8		5.2	5.9		5.7	32.6	32.0	33.6
Norland	1.0	2.9	4.5	1.6	2.6	5.3	3.0	3.5	5.8		3.5	5.7		3.6	31.3	31.3	30.2
ND 3324-2	2.2	4.8	4.0	3.6	4.1	4.8	5.0	4.1	5.4		5.3	5.5		5.9	32.4	33.5	34.4
ND 4122-2	1.8	3.8		3.5	4.1		2.9	5.2			5.3			5.7		33.3	34.3
ND 4121-25	2.4	3.3		1.7	3.2		3.2	4.0			4.8			4.8		33.3	33.3
ND 3676-20	..	3.3	3.0		2.9	4.5		3.6	5.7		4.2	5.7		4.0	34.0		32.4
ND 3740-11	1.0	1.1		1.6	2.5		2.5	3.3	2.5		3.6			4.1		31.2	29.7
ND 3694-6	2.7	4.2		4.9	5.3		4.1	5.5	4.1		5.2			5.6		33.9	33.2
F29-1	1.0	..		1.0	1.0		1.2	1.0	1.2		2.0			1.0		31.2	28.7
Average	1.8	3.5	4.2	2.8	3.7	5.2	3.6	4.1	4.8		4.5	5.7		4.7	32.7	.8	32.3

[1]Chip color (1-6) 1 dark brown, 6 light brown. Ratings of 3.5 and above are considered salable.
[2]Per cent based on 100 pounds of potatoes (average of several tests).

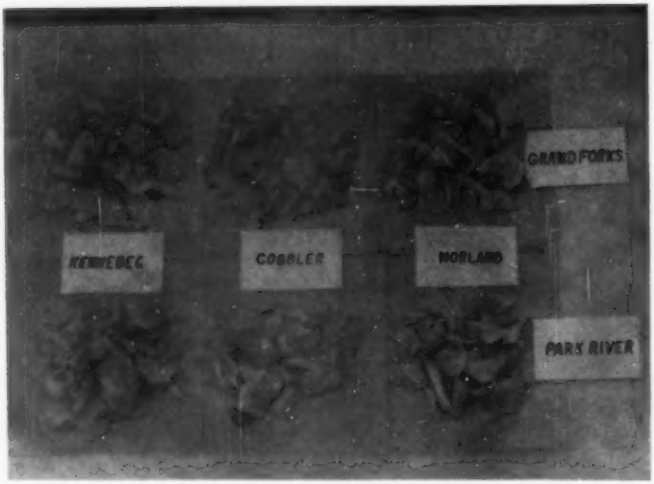

FIG. 3.—Chip color of Kennebec, Irish Cobbler, and Norland after being reconditioned for 4 weeks.

The selection ND 3676-20 and the varieties Norgleam and Nordak were quite erratic in producing light colored chips. The year and location seemed to influence their chip color. Norgleam produced a chip lighter in color than Nordak. The selections ND 4121-25 and ND 3740-11 produced medium-dark chips, and the selection F29-1 very dark chips when grown at both locations. Chips produced from the last three selections were not considered salable.

When chipped immediately out of cold storage at 38 to 40 F the selection ND 3694-6 produced chips of quite acceptable quality and good quality after a period of reconditioning. However, this selection lacks the horticultural characteristics needed to become a good chipping variety but may find its use as parental stock. Wright and Whiteman (9) studied the chipping quality of several potato varieties and found them all to make undesirable, dark colored chips when taken directly from storage at 40 F. A variety that would produce light chips out of cold storage would be a great advantage to the potato chip manufacturer.

The yield of Chips (Table 1 and 2) for the years 1957 through 1959 varied between location and varieties. Except for the year 1958, the trial at Park River produced a slightly higher average chip yield than that at Grand Forks. The higher chip yields may again be attributed to more favorable environmental conditions existing at Park River during 1957 and 1959. The varieties and selections with a high specific gravity produced the highest chip yield. Although variations did exist between years and locations, the Irish Cobbler and the selections ND 3676-20, ND 4122-2, and ND 3324-2 produced the highest chip yields.

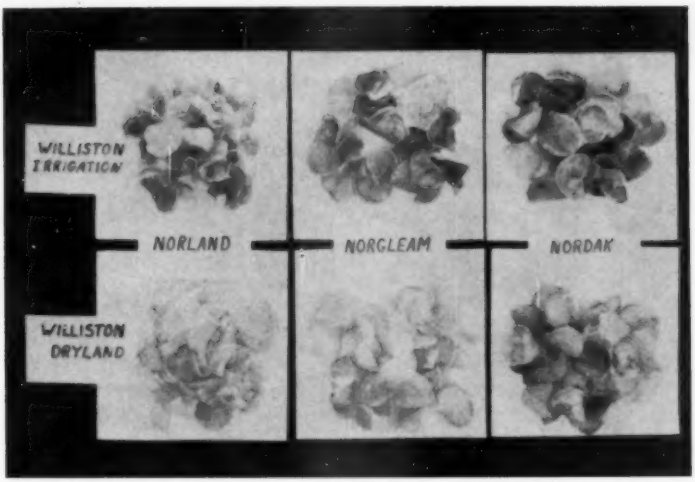

FIG. 4.—Chip color of Norland, Nordak, and Norgleam grown under Irrigation and Non-irrigation, Williston, North Dakota. Note the variety Nordak chipped quite dark when grown under both Irrigation and Non-irrigation.

Chipping tests of potatoes grown with and without irrigation at Williston, North Dakota

At Williston (western North Dakota), the varieties and selections grown without irrigation (Fig. 4) generally produced chips of lighter color than did those grown under irrigation (Table 3 and 4). The only exception was in 1959 when the irrigated trial produced chips of equal or lighter color than the non-irrigated trial. This may be attributed to the high seasonal temperatures and low rainfall existing during the 1959 season. According to Smith and Talburt (5), supplemented water added by irrigation will lower the soil temperature and offer conditions more conductive to good plant growth. These results were in general agreement with the results of Smith and Talburt (5), who in western New York found no consistent differences in color of chip from potatoes which had been irrigated compared with those which were not irrigated during the hot growing season in 1956.

Non-irrigated potatoes produced the highest chip yield, except in 1959 when the irrigated trial produced equal or better chip yields than the non-irrigated potatoes. According to Smith and Talburt (5), a soil well supplied with moisture during a hot growing season will result in lower soil temperature and probably a higher specific gravity which produces a higher yield of chips.

In the irrigated trial, the varieties Irish Cobbler and Kennebec produced the lightest colored chips after four weeks reconditioning, whereas the variety Norland and the selection ND 3324-2 generally produced chips of good salable color only after six weeks reconditioning. In the non-irrigated trial, the varieties Kennebec, Norland, Irish Cobbler, and the

TABLE 3.—*Chipping quality of varieties and selections grown under irrigation. Williston, North Dakota, 1957-1959.*

	Reconditioning periods												Average yields[2]		
	Color 2 weeks[1]			Color 4 weeks			Color 6 weeks			Color 8 weeks					
	1957	1958	1959	1957	1958	1959	1957	1958	1959	1957	1958	1959	1957	1958	1959
													%	%	%
Irish Cobbler	4.5	3.7	3.9	4.8	4.2	5.3	5.0	5.1	5.7	5.4	..	5.9	33.1	34.1	36.1
Kennebec	..	5.3	3.3	..	6.0	3.9	..	6.0	6.0	..	..	5.4	..	34.9	34.6
Nordak	2.0	1.0	1.0	2.0	3.2	2.3	2.5	3.2	2.0	2.8	..	4.3	31.8	32.8	33.6
Norgleam	1.5	1.0	1.0	2.5	2.3	2.0	2.1	3.0	1.7	3.0	..	3.2	31.3	34.1	34.0
Norland	3.3	1.5	4.4	1.5	2.3	5.4	3.3	3.0	5.4	3.0	..	5.0	28.4	31.9	32.4
ND 3324-2	2.0	1.3	1.6	4.3	3.4	3.1	2.0	5.5	4.0	3.0	..	5.2	30.7	34.7	33.2
Average	2.7	2.3	2.5	3.0	3.6	3.7	3.0	4.3	4.1	3.4	..	4.8	31.1	33.8	34.0

[1]Chip color (1-6) 1 dark brown, 6 light brown. Ratings of 3.5 and above are considered salable.
[2]Per cent based on 100 pounds of potatoes (average of several tests).

TABLE 4.—*Chipping quality of varieties and selections grown under non-irrigation. Williston, North Dakota, 1957-1959.*

	Reconditioning periods												Average yields[2]		
	Color 2 weeks[1]			Color 4 weeks			Color 6 weeks			Color 8 weeks					
	1957	1958	1959	1957	1958	1959	1957	1958	1959	1957	1958	1959	1957	1958	1959
													%	%	%
Irish Cobbler	5.8	4.5	1.6	6.0	5.1	4.5	6.0	5.8	6.0	6.0	.	5.9	35.7	33.9	35.9
Kennebec	..	5.8	5.8	..	5.5	6.0	..	6.0	6.0		..	6.0	..	34.2	36.9
Nordak	3.3	1.9	1.0	4.7	3.2	1.0	5.9	2.9	1.0	5.9	..	1.2	35.0	32.4	31.7
Norgleam	4.5	2.6	1.0	5.7	2.9	1.5	6.0	3.4	1.5	5.9	..	1.4	35.2	32.5	31.3
Norland	5.5	4.0	4.3	6.0	5.0	4.9	6.0	4.8	5.1	6.0	..	5.7	33.4	32.5	30.9
ND 3324-2	6.0	4.6	1.8	6.0	5.0	3.7	6.0	6.0	4.5	5.9	..	5.4	34.6	35.8	33.0
Average	5.0	3.9	2.6	5.7	4.5	3.6	6.0	4.8	4.0	5.9	..	4.3	34.8	33.6	33.3

[1]Chip color (1-6) 1 dark brown, 6 light brown. Ratings of 3.5 and above are considered salable.
[2]Per cent based on 100 pounds of potatoes (average of several tests).

selection ND 3324-2 all produced chips of very light salable color after a maximum of four weeks reconditioning.

Summary

Potato varieties and selections grown in North Dakota were tested for chipping quality at North Dakota State University.

In the 1957 through 1959 tests, the varieties Irish Cobbler, Kennebec, and selection ND 3324-2 produced light-colored chips after reconditioning four weeks. ND 3324-2 was superior to Irish Cobbler in shape and type, higher in specific gravity than Kennebec, and earlier in maturity than either variety. The variety Irish Cobbler and selections ND 3324-2, ND 4122-2, and ND 3676-20 had the highest chip yields.

The varieties Kennebec, Norland, Irish Cobbler, and ND 3324-2 grown under non-irrigation produced light-colored salable chips after four weeks reconditioning. In the irrigated trial, Norland and ND 3324-2 had to be reconditioned six weeks to achieve good salable color.

Literature Cited

1. Akeley, R. V., F. J. Stevenson, and D. Merriam. 1955. Effect of planting dates on yield, total solids, and frying and chipping qualities of potato varieties. Am. Potato J. 32: 441-447.
2. Findlen H. 1960. Effect of fertilizer on the chipping quality of freshly harvested and stored Red River Valley potatoes. Am. Potato J. 37: 85-89.
3. Shallenberger, R. S. and O. Smith. 1955. Browning reaction in potato chips. Am. Potato J. 32: 428.
4. Schwimmer, S., C. E. Hendel, W. O. Harrington, and R. L. Olson. 1957. Interrelation among measurements of browning of processed potatoes and sugar components. Am. Potato J. 34: 119-132.
5. Smith, O. and W. F. Talburt. 1959. Potato processing. The Avi Publishing Co., Westport, Connecticut.
6. Smith, O. 1955. How to grow and store potatoes for the chip industry. Am. Potato J. 33: 265-271.
7. Smith, O. 1957. Potatoes and NPCI research. Nat'l. Potato Chip Inst. Proc. Prod. and Tech. Div. meeting. 1956, 3-5.
8. Watada, A. E. and R. Kunkel. 1955. The variation in reducing sugar content in different varieties of potatoes. Am. Potato J. 32: 132-140.
9. Wright, C. R. and T. M. Whiteman. 1954. Chipping quality of eight potato varieties as affected by source and storage temperature. Circ. No. 936. U. S. Dept. of Agriculture.

NEWS AND REVIEWS

IMPROVED HANDLING AND PACKAGING METHODS FOR POTATOES: HOW IT IS DONE IN MAINE[1]

EDWARD F. JOHNSON[2]

The business of growing, storing, processing, packaging, and shipping of 15 to 16% of the nation's total potato production is the principal occupation of the agricultural population of Maine's northernmost county—Aroostook. The eastern and northern parts of this county are a "natural" for potato production with inherent soil and climatic conditions particularly well suited for the potato plant and tuber growth. Storing this crop at a recommended 38 to 45 F. presents few problems from the months of October until June. Consequently, the business of potatoes has become highly intensified in this section of Aroostook, which accounts for about 95% of Maine's entire production.

Potatoes are Maine's number one field crop. The 1959-60 season plantings totaled 142,000 acres and produced just over 34 million hundredweight. Of this quantity, approximately 18,466,000 hundredweight were shipped to market as tablestock, with the remainder being handled primarily through the channels of seed stock, potato starch, and processed potato products.

Potatoes have been produced comercially in Aroostook County for nearly 100 years. They were first transported to market in bulk, largely in common box cars or in reefer cars. Not until 1924, when shippers started to use 165-pound burlap bags, were potatoes marketed in a package. Three or four years later, the 150-pound bag came into use, then the 120-pound and next the 100-pound sack. About 1930, bag sizes for tablestock potatoes dropped from the 100-pound sacks to 50-pound burlap sacks and 50, 15, and 10-pound paper bags.

The package assortment has continued to expand during the past few years with the introduction of container materials other than burlap and paper (Table 1).

The several varieties of potatoes raised in Maine and the several grades under which they can be shipped add to the diversification. The Katahdin is the leading variety at present and comprises about 70% of the total shipments. The Russet Burbank is the next most prominent variety shipped as tablestock and constitutes about 5% of total shipments. Ten other varieties, predominently of the round white type, make up the remainder of potatoes from Maine.

Potatoes are shipped from Maine either under federal grades or the higher quality Maine grades. Variations in tuber size limitations increase the total to at least 13 different grades of the round white type and 16 grades of the long type Russet Burbank variety. In the round white varieties, the U. S. No. 1 grade is the lowest grade that is shipped to the tablestock market from Maine—that is, there are no shipments of

---

[1]Reprinted with permission from Produce Marketing, Vol. 4, No. 3.
[2]Maine Potato Handling Research Center.

TABLE 1.—*Size and type of packages in which Maine potatoes were shipped to the tablestock market during 1958-59 season.*

Package size	Type of package							
	Paper	Paper with mesh front	Film	Mesh	Burlap	Crates	Boxes	Bulk
Pounds	Per cent of total							
4	*		*					
5	.8	.1	2.6	*				
10	19.7	5.7	4.2	1.4				
15	4.0	.6	*					
25	4.0	2.3	*					
40							*	
50	42.6	2.1			1.8	*	*	
60	.2							
75					.3			
100					7.2	.2	*	
110						*		
165					*			
2000							.2	
Bulk								*

*Less than .05 per cent.

round white potatoes from the state as U. S. No. 2, Commercial, or Utility as there are in most other growing areas. In addition, the U. S. No. 1 grade has had, by the Maine Marketing Order, a minimum size of 2¼ inches diameter rather than 1⅞ inches and a maximum size of 4 inches diameter during the past few years.

MANY SHIPPERS

With this diversity in size and type of packages, and in variety and grades of potatoes being offered—either washed or unwashed, it might follow that there are a large number of separate packing operations. The total number of shippers for the 1957-58 season was approxiately 1,075. About 53% of this number shipped 10 carlots or less during the season, 35% shipped 11 to 100 carlots, 10% shipped 101 to 500 carlots, and 2% shipped over 500 carlots. The total number of shippers usually changes from year to year with the increase or decrease occurring primarily in the size category of "10 carlots or less per year." Shippers in this group generally pack potatoes in packages of 50 pounds or more. The larger shippers are usually more diversified and offer potatoes in a variety of packs.

A new idea in containers has come into use in Maine recently, designed specifically for those buyers who wish to package their potatoes nearer the retail market. This container is referred to, variously, as a pallet box, tote box, bin box, bulk bin, or pallet bin. The box is made of wood and is handled with the aid of an industrial forklift truck. The potatoes shipped in these bulk containers are sized and graded to meet the same USDA and Maine requirements as are potatoes packed in smaller packages at Maine shipping points.

Pallet Bins

The first commercial shipment of potatoes in pallet boxes from Maine was made by railway car in December, 1956, and was shipped from Russell Brothers in Fort Fairfield, Maine, to H. W. Steane Co., East Hartford, Connecticut. This car was loaded with 20 boxes each containing about one ton of potatoes. The outside box dimensions were 48 by 42½ inches along the base and 50½ inches high, including the skid. They were placed two boxes wide and ten long in the car. The skids of the boxes were placed alternately parallel and perpendicular to the length of the car in loading, so that the 20 boxes would fit within the available space.

In November, 1957, the first truckload of potatoes shipped in pallet boxes moved between the same two enterprises. The boxes were of the same dimensions and capacity as those shipped by rail car. All the boxes in the load were positioned with the skids parallel to the length of the trailer, and the 14 boxes were fitted two wide and seven long in the van. An extra 105 50-pound bags were added to bring the gross weight of this truck load up to 60,000 pounds. Presently, the number of boxes in a truckload varies between 12 and 16, depending upon the length of the van. Bagged potatoes to bring the load up to weight are generally necessary only with the 12 and 14 box loads.

In 1959, a grading line was set up at Potatoes, Inc., Presque Isle, Maine, for the specific purpose of filling pallet boxes. Sized, washed, and graded potatoes are moved on a reversing-flow conveyor to either of two boxes through baffle chutes which deflect the fall of the tubers and ease their descent into the box. As the box fills, the chute is raised to keep above the level of the potatoes. The filled boxes are weighed and loaded into a van.

In 1960 the capacity of the pallet box used for shipping was increased by adding four inchs to the height. The boxes now in use hold 2,200 pounds. This reduces the number and frequency with which bagged potatoes are needed to bring the truckload up to weight. At present, all pallet box shipments are made by truck.

Bulk Potato Car

Through close railroad cooperation, bulk lot shipments are again being made from Maine in rail cars. The new version of bulk car, constructed by the Bangor & Aroostook Railroad, is filled and emptied with a built-in conveying system. Loading is accomplished by two conveyors, one in either end of the car, that are raised as the load builds up. The potatoes are removed from the conveyors by a device which can be moved to any position along the length of the conveyor. Unloading is handled by conveyors in the floor that move the potatoes to the center of the car and then to either doorway. The floor of the car has been inclined so that the potatoes flow by gravity onto the unloading conveyors.

The bulk car has a capacity of nearly 70,000 pounds of potatoes. This is nearly 20,000 pounds more than is commonly carried in cars of bagged potatoes. These potatoes are sized and graded to meet at least the U. S. No. 1 grade.

Sprout Inhibitors

As spring approaches, potatos can be obtained from Maine which have been treated with a sprout depressant, such as MENA, or a sprout inhibitor, such as MH-30 or CIPC. Use of sprout inhibitors allows potatoes to be held in storage even during the warm summer months, and thus Maine potatoes can be obtained for market the year around.

Potato processing is expanding rapidly, and potatoes in processed form are continuing to command an increasing share of the market, but as long as potatoes are consumed as a fresh product, Maine offers them "as you want them."

INGROWN SPROUTS IN POTATO TUBERS: FACTORS ACCOMPANYING THEIR ORIGIN IN OHIO[1]

RALPH MARSHALL DAVIS, JR.[2]

In February, 1961, an excessive amount of internal or ingrown sprouts in potatoes was reported for several warm (55-60 F) storages in Ohio, as well as in other states. The condition, as herein described, was observed in Katahdin potatoes grown and stored in five locations and in Kennebec at a sixth location, all in Ohio. It has been reported in Ohio to occur also in Sebago. Gager (1) investigated an almost identical disorder in Green Mountain variety stored in a basket in a light, unheated room. Ingrown sprouts, strongly tuberized, were observed by Stewart (4) in the variety Sir Walter Raleigh.

The ingrown sprouts are not adventitious; that is, they originate at regular eyes from buds which would normally grow outward. The sprouts may branch within the tuber, and often the tips emerge. Although imbedded in tuber tissue, they behave, geotropically, as normal stems. However, there is a commonly observed tendency for basal buds of some sprouts arising in storage to develop stolon-like characteristics, and this may be a factor in the present problem. Gager (1) suggested a reversal of polarity, but was not convinced of it. For the most part the internal sprouts have grown into the parent tuber, but frequently similar sprouts penetrate an adjacent tuber.

Ingrown sprouts originate at eyes which have partially developed external sprouts. In the instances being reported, the growing points of the external sprouts are moribund or dead. The more dense the cluster of sprouts at a given eye, and the more the necrosis is restricted to the apices, the more probable is the occurrence of one or more ingrown sprouts. The sprouts arise mostly from axillary buds on the partially developed external sprouts. The axillary buds must have been stimulated to activity after the apical meristem of the parent sprout began to deteriorate. The apical meristem of the ingrown sprout does not have the pathological appearance typical of the external sprouts, unless and until it emerges.

Evidently the sprouts can penetrate an intact periderm, and do so in a majority of cases. Once inside, further penetration occurs as a result of elongation aided by the splitting action of radial expansion abnormally close to the tip. Gager (1) attempted to determine whether or not the penetration was aided by enzymatic activity and concluded that it was not.

It is reasonable to enquire how the sprout gains the mechanical advantage necessary for penetration of the periderm. In most cases, the eye from which the ingrown sprout originates is tightly pressed against another tuber. Thus the pile pressure opposes the expansion of imprisoned buds and permits their expanding force to be exerted fully on the periderm. The direction of least resistance is the one which is pursued. Penetration is a matter of probability, depending on the circumstances of the individual situation.

[1]Accepted for publication April 3, 1961. Journal Article No. 47-61.
[2]Department of Horticulture, Ohio Agricultural Experiment Station, Wooster.

Apparently pile pressure is not necessary. Potatoes with ingrown sprouts have been found near or at the top of the pile. Where this occurs, the eye of origin is profusely and densely sprouted. The hardness of these external sprouts is greater than that of the tuber. The external sprouts are usually short (¾"-1") and show typical tip injury. Axillary buds pressed between the cluster and the periderm are healthy and vigorous and are often inverted in the growth adjustments occurring in the unnaturally constricted conditions. The cluster proliferates in a basipetal direction since the stimulation of axilllary buds proceeds basipetally and these buds in turn are successively subjected to the tip-injuring influence. The cluster develops a strong pivotal attachment at the eye and expands against the periderm. The expanding force of an occluded and protected bud is transferred in an arc through the compressed cluster to other portions of the periderm and is thus opposed until it has gathered pressure sufficient for penetration.

Among the observed cases, some ingrown sprouts originated in deep eyes in such a way that their initial growth introduced the tip into an invagination of the tuber surface bounding the eye. Such a circumstance allowed the radial expansion of the sprout to split the tuber at that point and penetration was effectuated. It is possible, though not observed, that some buds, perhaps adventitious, were initiated beneath the periderm, in the vascular region of the eye. Gager (1) mentions this possibility and Hardenburg (2) attributes an extensive incidence of ingrowing roots in potatoes to initiation beneath the periderm.

Gager (1) was not able to induce sprouts to penetrate the periderm by binding two potatoes together. It is possible, however, that such penetration might have occurred if he had inhibited the growth of sprouts at exposed eyes.

The Katahdin potatoes at three locations upon which these observations were made had been treated with 3-chloro-isopropyl-N-phenyl carbamate, (CIPC), a sprout inhibitor. The literature on the use of CIPC is considerable, and no report of internal sprout growth as a consequence of experimental treatment is to be found at present (3). It is possible to conceive of several agents, including light, brief freezing, volatile chemical compounds, and slow-moving pathogens, which might depress or injure the tip growth of developing sprouts.

Summary

The factor or conditions necessary for the internal growth of sprouts observed in Ohio appear to be these:

(a) An agent which injures and destroys the dominance of, the apical meristem of exposed sprouts, without completely inhibiting the expansion of basal portions of such sprouts, and without inhibiting the development of unexposed buds.

(b) A set of circumstances which allow the full force of the expanding sprout to be exerted on the periderm. This condition may be satisfied by the pressure of another potato against the eye of origin, by the mechanical components of a basipetally expanding cluster of buds, or by one or two less complex means.

Literature Cited

1. Gager, C. S. 1912. Ingrowing sprouts of *Solanum tuberosum*. Botan. Gaz. 54: 515-524.
2. Hardenburg, E. V. 1940. A rare abnormality in stored potato tubers. Proc. Am. Soc. Hort. Sci. 38: 513-514.
3. Sawyer, R. L. 1961. Relation of Chloro IPC for potato sprout inhibition to internal sprouting of potatoes. Am. Potato J. 38: 203-207.
4. Stewart, F. C. 1918. Tubers within tubers of *Solanum tuberosum*. Brooklyn. Botan. Mem. 1: 423-426.

WORK SESSION ON "DEVELOPING POTATOES FOR PROCESSING"

A work session dealing with the general topic "Developing Potatoes for Processing" was held at Beltsville, Md., on May 5, 1961. The session was organized by A. E. Kehr, R. V. Akeley, and G .V. C. Houghland.

V. R. Boswell, in his opening remarks, said that such a work session had been under consideration for some time to help meet the need to develop potatoes better adapted to the rapidly expanding trend toward processed potato products. The potato processing industry is recognized as one of the fastest expanding agricultural industries creating a need for changed emphasis in potato improvement.

The meeting was called particularly for the purpose of bringing scientists from several disciplines together for, discussing problems relating to enzyme systems of potatoes, the effect of such enzymes on potatoes for processing and genetic control of enzyme systems, and for coordinating private, industrial, and public research in this area. The objective was to summarize what is known pertinent to these problems and what might be done to breed potatoes for processing industries.

The following conferees were present:

R. V. Akeley, Leader, Potato Investigations, ARS, Beltsville, Maryland.

V. R. Boswell, Chief, Vegetable and Ornamental Reseearch Branch, ARS, Beltsville, Maryland.

C. C. Craft, Market Quality Pioneering Laboratory, AMS, Beltsville, Maryland.

E. F. Hoover, Chief Chemist, Wise Potato Chip Company, Berwick, Pennsylvania.

G. V. C. Houghland, Potato Investigations, ARS, Beltsville, Maryland.

A. E. Kehr, Assistant Chief, Vegetable and Ornamental Research Branch, ARS, Beltsville, Maryland.

J. M. Lutz, Assistant Chief, Horticultural Crops Branch, AMS, Beltsville, Maryland.

A. Lloyd Ryall, Chief, Horticultural Crops Branch, AMS, Beltsville, Maryland.

Sigmund Schwimmer, Chemist, Vegetable Laboratory, WURDD, Albany 10, California.

R. H. Treadway, Plant Products Laboratory, EURDD, Philadelphia 18, Pennsylvania.

P. A. Xander, Director of Research and Development, Wise Potato Chip Cmpany, Berwick, Pennsylvania.

A summary of the various presentations follows:

Kehr. It was explained that the purpose of the conference was "to advise and consult." The knowledge concerning genetic control of enzyme systems was reviewed. He indicated that metabolism proceeds in a stepwise mannar. Certain of the enzyme systems in plant and animal life are controlled by specific genes.

Blocks may appear in a chain of reactions when a mutation occurs. Such blocks are usually controlled by recessive genes. Environment can also be an influencing factor.

Examples were given as to how single recessive genes can be the controlling mechanisms that cause: diabetes and hemophelia in man; development of yellow fat in rabbits; development of cyanosis in clover. Flowers can be bred for color, changes being brought about, for example, by substituting hydroxyls at proper places in the benzine rings of the compound pelargonidin. Among other biochemical reactions, that of phenyl alanine through tyrosine to "DOPA" and melanine was reviewed. Operation of a recessive gene in the step from the DOPA to melanine gives rise to albinos.

Houghland. The main responsibilities of Potato Investigations in Beltsville are (i) breeding improved varieties, (ii) disease control, and (iii) conducting studies on production problems including nutrition and culture of the crop. While the interests go beyond these subjects, enzyme chemistry is not included in the investigations. Potato Investigations personnell are prepared to help by supplying raw material at any stage of growth and potatoes from specific family lines having certain known characteristics. The group might also be able to supply a limited amount of raw material grown under nutrient control in a greenhouse. In a year or two, raw material can be supplied from the new Industrial Potato Breeding Program, the aim of which is to develop varieties with exceptionally high starch content. The scientists in Potato Investigations are prepared to offer 35 years of practical experience in researching all the important steps in potato production.

Experiments are being made with the germination of seed potatoes in sucrose solutions of different osmotic tensions. This technique has been beneficial in grain breeding to develop drought and frost resistance.

Akeley. Qualities that a seedling must possess to be worth ultimate introduction as a new variety were discussed. The seedling must: (i) yield well; (ii) produce tubers with a smooth surface and regular shape to permit ready peeling; (iii) have resistance to leafroll, brown spot, and ring rot; (iv) be free of corky ring spot and deep-pitted scab; and (v) have low susceptibility to blackspot. Any new variety must also be usable for chip manufacture, as gauged principally by low color of the chips. Tubers from seedlings are fried into chips both at harvest time and after cold storage and reconditioning. Methods are needed for predetermining whether potatoes will accumulate sugars in cold storage. For the country as a whole, Irish Cobbler and Kennebec are the preferred varieties for processing. In the breeding program, the assumption is made that any variety good for processing will also be good for tablestock.

It formerly required 10 years or longer to develop a new variety from origin to acceptance. This period of time has now been reduced to 6 years. From 30,000 seedlings, approximately 250 selections that show promise are typically made. One may expect 2 or 3 potentially acceptable varieties from these selections.

Lutz. The nature of the biological and agricultural engineering research in the Marketing Service was outlined. This research includes effects of handling methods and storage and transit environments on quality

of potatoes for processing. This past season internal sprouting was a serious problem in potatoes stored at high temperatures. Early-summer potatoes should be stored and transported at 65 to 70 F. Higher temperature will increase decay and lower temperature will cause sugar accumulation in this typye of raw material.

Craft. The industry wants high starch-low sugar potatoes with a long dormant period. The industry would like to store the late crop for a longer period and have high solids in early potatoes. Enzymes increase the rate at which the equilibrium of a reaction is attained but do not alter the reaction.

Some people will disagree with the idea that genes and enzymes have a 1:1 relationship. It must be watched that any alteration in the enzyme system of potatoes is not lethal. The balanced physiological system protects against damage by freezing, heat and dehydration.

Schwimmer. High sugar content, especially sucrose, in potatoes is associated in general with stresses such as high and low temperatures, desiccation, and exposure to ionizing radiation. In addition, Dr. Samotus of the Department of Agricultural Technology, College of Agriculture, Krakow, Poland, who conducted research at the Western Regional Research Laboratory on the carbohydrates and phosphorus compounds of potato, found high levels of sugar, mostly sucrose, in immature potatoes. Immature potatoes accumulate predominantly fructose rather than sucrose upon storage at low temperatures. Mature potatoes stored in nitrogen for 5 to 6 weeks at 32 F. lost starch more slowly than potatoes stored in air but unlike air-stored tubers do not accumulate sugar. Instead the starch which disappears is apparently converted to volatile substances amounting to 8% of the original weight of total solids.

A study of the chemical distribution of the phosphorus compounds in potatoes revealed that they are more or less equally distributed among: (i) starch-bound phosphorus, (ii) phytic acid (and to lesser extent other acid-soluble phosphate esters), (iii) inorganic orthophosphate, and (iv) acid-insoluble non-starch phosphorus-containing compounds which include nucleic acids, phospholipids, and phosphoproteins. The starch-bound phosphorus is linked by ester formation to about 1 in every 150 glucose residues of the amylopectin moiety of starch. Upon storage at low temperature, the loss of starch-bound phosphorus can largely be accounted for by an increase in inorganic orthophosphate whereas losses in phytic acid phosphorus appear to be related to corresponding increases in component (iv).

Enzymes which can account for the presence of and interconversions of starch and sugars in potatoes have been demonstrated in the tubers. The amylose moiety of starch can be synthesized by phosphorylase or P-enzyme according to the equation:

$$\text{Glucose-1-phosphate} + \text{primer} \rightleftharpoons \text{amylose} + \text{orthophosphate}.$$

Potatoes contain Q-enzyme, which can synthesize amylopectin from amylose, and R-enzyme, which can produce unbranched dextrins and may be the source of supply of primers for P-enzyme action. Recent evidence strongly suggests that the P-enzyme may be concerned mainly with the

degradation of starch, whereas a special enzme synthesizes starch (amylose) according to the following equation:

$$\text{Uridine diphosphate glucose (UDPG)} + \text{primer} \rightleftharpoons \text{starch} + \text{uridine diphosphate (UDP)}$$

UDPG is also involved in the syntheses of sucrose in plants:

$$\text{UDPG} + \text{fructose} \rightleftharpoons \text{sucrose} + \text{UDP}$$

Finally, potatoes contain invertase, an enzyme which converts sucrose to glucose and fructose.

Work on potato enzymes at the Western Regional Research Laboratory has been directed towards the elucidation of the influence of factors in potatoes which affect the activity of enzymes in relation to their role in sugar-starch interconversions. Some of the findings are as follows:

(1) The level of inorganic phosphate influences the rate and extent of formation of amylose by the P-enzyme but does not cause a true inhibition of the action of this enzyme.

(2) Chlorogenic acid, a polyphenol present in potatoes, exerts a true and potent inhibitory action on P-enzyme. Polyphenols may be involved in control of starch-sugar interconversions.

(3) The sucrose-synthesizing enzyme has been demonstrated in potatoes. A good sugar former, White Rose, contained 4 times as much enzyme as a poor sugar former, Washington Russet.

(4) Potatoes stored at low temperatures exhibit more (4 to 5-fold) invertase activity than do potatoes stored at room temperature.

(5) The presence in potatoes of a potent high molecular weight inhibitor seemingly may be involved in control of starch-sugar interconversions.

Xander and Hoover. Like the entire industry the Wise Potato Chip Company is interested in making uniformly colored chips with a high flavor level. It would like to store potatoes at 50 F. and recondition at 70 F., while avoiding use of a sprout inhibitor. The Wise Company has found that to get proper reconditioning, New Jersey potatoes need added manganese in the fertilizer.

Wise Potato Chip Company is cooperating with the University of Massachusetts Food Technology Departent in a study of oxidative rancidity development in chips by the use of gas chromatography. The findings are similar to those of Buttery with potato granules, that is, the changes are mainly in the fat fraction.

The Wise Potato Chip Company started investigating the compositional characteristics of potatoes on a yearly basis in 1957. The purpose is to study the influence of individual or groups of compounds on the chipping color, with the hope that the results may lead to eventual methods of control. The compositional research during the 1957-59 growing seasons was mainly of a screening nature. Consistent correlations were found between chip color and the concentrations of glucose and fructose. Less consistent correlations were found between chip color and concentrations of basic amino compounds, ascorbic acid, polyphenols, certain protein constituents, and specific trace metals.

Potatoes from 2 or 3 varieties from each of 3 growing areas (Florida, Virginia, and Pennsylvania) were used in the 1960 studies. Analysis was made at time of harvest. The samples were then divided with one portion stored at 70 F. and another at 40 F. Sub-samples were withdrawn at intervals of 4 weeks and analyzed. After 8 weeks the 40 F. material was placed in a 70 F. room for reconditioning. The total length of storage was 16 weeks. Sebago, Onaway, Pungo, Delus, and Huron varieties were tested. The data obtained were lumped according to storage temperature and analyzed statistically.

The following are some of the more striking relationships found with the 1960 raw material in summation of "sample correlation coefficients from 70 F. storage." On basis of 35 observations for each factor all correlation coefficients are significant at the 1% level.

Chip Color vs. Enzymes

Chip color vs. invertase	+0.55*
Chip color vs. acid phosphatase	—0.54
Chip color vs. sucrose UDP-transglucose	—0.53

Chip Color vs. Sugars

Chip color vs. reducing sugars	+0.90
Chip color vs. glucose	+0.88
Chip color vs. fructose	+0.75

Chip Color vs. Other Constituents

Chip color vs. histidine	+0.64
Chip color vs. total polyphenols	+0.53

Enzymes vs. Sugars

Invertase vs. total reducing sugars	+0.76
Invertase vs. glucose	+0.74
Invertase vs. fructose	+0.65
Sucrose UDP-transglucose vs. sucrose	+0.48

*Positive sign denotes darker colored chips related to higher concentration of enzyme.

During the 1960 growing season, 52 selected seedlings from the station at Presque Isle, Maine, were examined by the Wise Company for chipping color and amounts of reducing substances and enzyme potencies. All these seedlings produced as part of the National Potato Breeding Program gave light-colored chips. In this set of samples chip color vs. invertase gave a correlation coefficient of +0.48 and chip color vs. total reducing sugars, +0.48. Both are significant at the 1% level.

These data seem to establish an enzymatic basis for chipping color and provide a starting point for investigations to determine the feasibility of genetic selections of potato varieties for chipping quality. The following idea is perhaps of merit:

If accelerated conditions can be found to develop the potential of invertase, commensurate with what is realized during cold storage, then development of new varieties can be hastened and testing of potato lots accelerated.

R. H. Treadway reviewed the proceedings of the day and made a written summary.

GROWING ALFALFA SUCCESSFULLY

WHAT A new motion picture, "Growing Alfalfa Successfully," is now available for your showing. Produced by the American Potash Institute in close cooperation with official agricultural specialists, the new 16mm color movie is 25 minutes long and features special time-lapse photography to show how the plant grows and feeds. From the main movie, two 16mm shorts have been developed—"Alfalfa, Queen of the Forages" and "Good Alfalfa Requires Good Fertility"—which run 10 minutes each and contain the same information as the main movie in two different condensed versions.

HOW Any one of the three movies can be booked free of charge by contacting Department BC, American Potash Institute, 1102 16th St., N. W., Washington 6, D. C., giving a date and alternate desired for showing, as well as name and organization represented.

ANOTHER SERVICE OF

AMERICAN POTASH INSTITUTE, INC.

SERVING AGRICULTURE FOR OVER TWO DECADES

1102 Sixteenth St., N. W. Washington 6, D. C.

Member Companies: American Potash & Chemical Corporation • Duval Sulphur & Potash Company • Potash Company of America • Southwest Potash Corporation • United States Borax & Chemical Corporation

NOTICE

Membership dues and/or subscription to the American Potato Journal will increase to $6.00 per year effective January 1, 1962 ($7.00 in foreign countries) by action of the membership at the annual meeting, July 26, 1961.

ERRATA

The name S. E. Sides should be added to the Machinery and Equipment Committee listed on page 375 of the October issue.

The article about Sam Kennedy, pages 313-314, September, 1961, was written by James C. Horton, Iowa State University, instead of August Kehr as indicated.

From the Nation's Most Complete
Seed Potato Program

MAINE

Proudly Offers

CERTIFIED SEED POTATOES

of 30 Varieties

★ GREENHOUSE AND FIELD INDEXING

★ SUPER FOUNDATION SEED FARM

★ FOUNDATION ROGUING SERVICE

★ GENERATION I and II PROGRAM

★ FLORIDA TEST

★ CERTIFIED BY EXPERIENCED *SEED* INSPECTORS

Paul J. Eastman, Chief
Division of Plant Industry

MAINE DEPT. OF AGRICULTURE

AUGUSTA, MAINE

Telephone: MA 3-4511 Extension 333

Increase potato profits Treat seed pieces with Du Pont SEMESAN BEL®

Only "Semesan Bel" helps control all these diseases:

Bacterial ring rot	Seed-borne scab
Black leg	Fusarium
Rhizoctonia	Verticilium wilt

• **Improves your yield and profit**—Time and again in field tests, under actual growing conditions, seed pieces treated with "Semesan Bel" have given better yields than pieces treated with other disinfectants *or* protectants.

• **Gives better quality**—Watch your yield of No.1 potatoes rise when you plant seed pieces treated with "Semesan Bel"! And that's where you make your money!

"Semesan Bel" is easy to use. It mixes easily with water: you simply dip seed pieces into the solution, drain and let dry. No long soaking needed. One pound of "Semesan Bel" in 7½ gallons of water will treat 60 to 80 bushels (36 to 48 sacks) of seed. Get a supply of Du Pont "Semesan Bel" from your dealer and see for yourself.

On all chemicals follow labeling instructions and warnings carefully.

DU PONT
REG. U.S. PAT. OFF.
BETTER THINGS FOR BETTER LIVING
...THROUGH CHEMISTRY

SEMESAN BEL®
seed disinfectant

FEATURING the famous Lockwood Variable-Speed Drive which regulates the flow of potatoes to coincide with any soil conditions

ALL NEW depth gauge takes the guesswork out of digging.

MODEL 1422-23 in two styles:
—the 26" single-row direct harvester.

—26" and 30" pickup models for bulk loading 2 rows already dug.

Lockwood

"SPOTLIGHTS"

the sturdy TRACTOR-MOUNTED HARVESTER

which gives

immediate performance.

Complete line of potato and onion equipment

LOCKWOOD GRADERS

HOME OFFICE GERING, NEBRASKA